



712CD

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Bayesian Causal Modeling Extended and Applied to Resource Requirements

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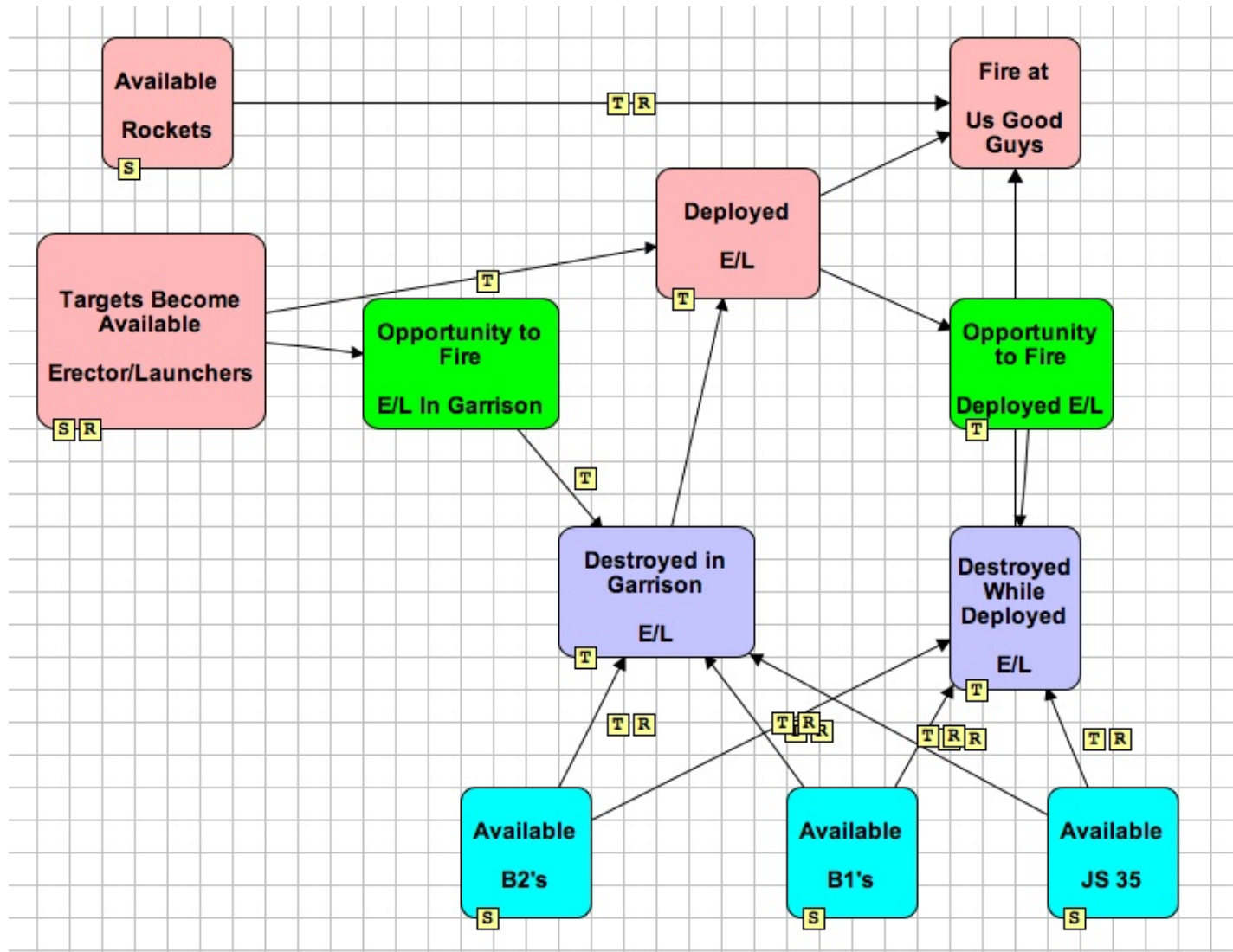
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Resourced Bayesian Networks

- Missile Defense Example
- How it has been done
 - Extension to Bayes Technology
 - Resource Constrained Persistence
- Relationship to other common approaches

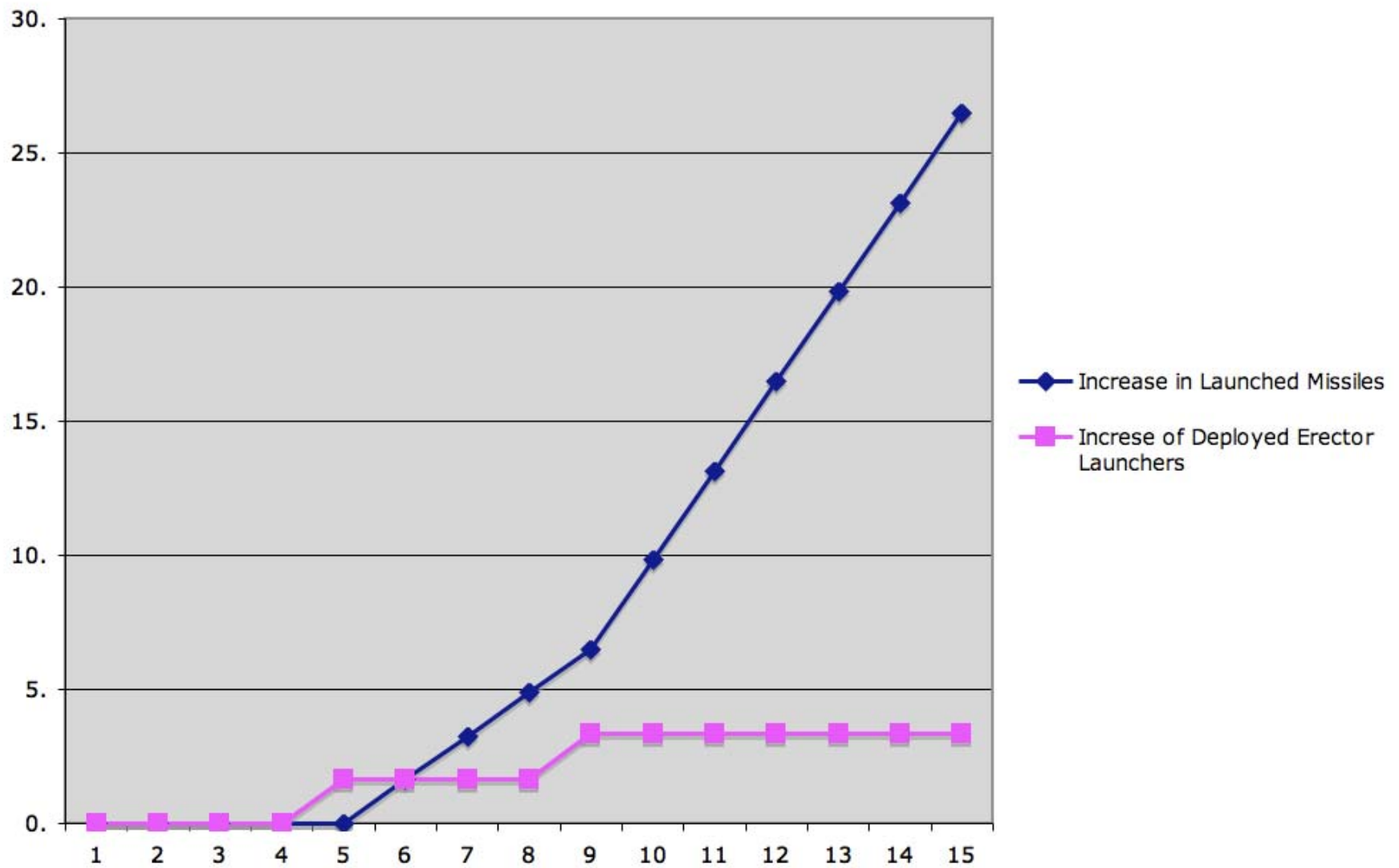
Mini Kill Chain



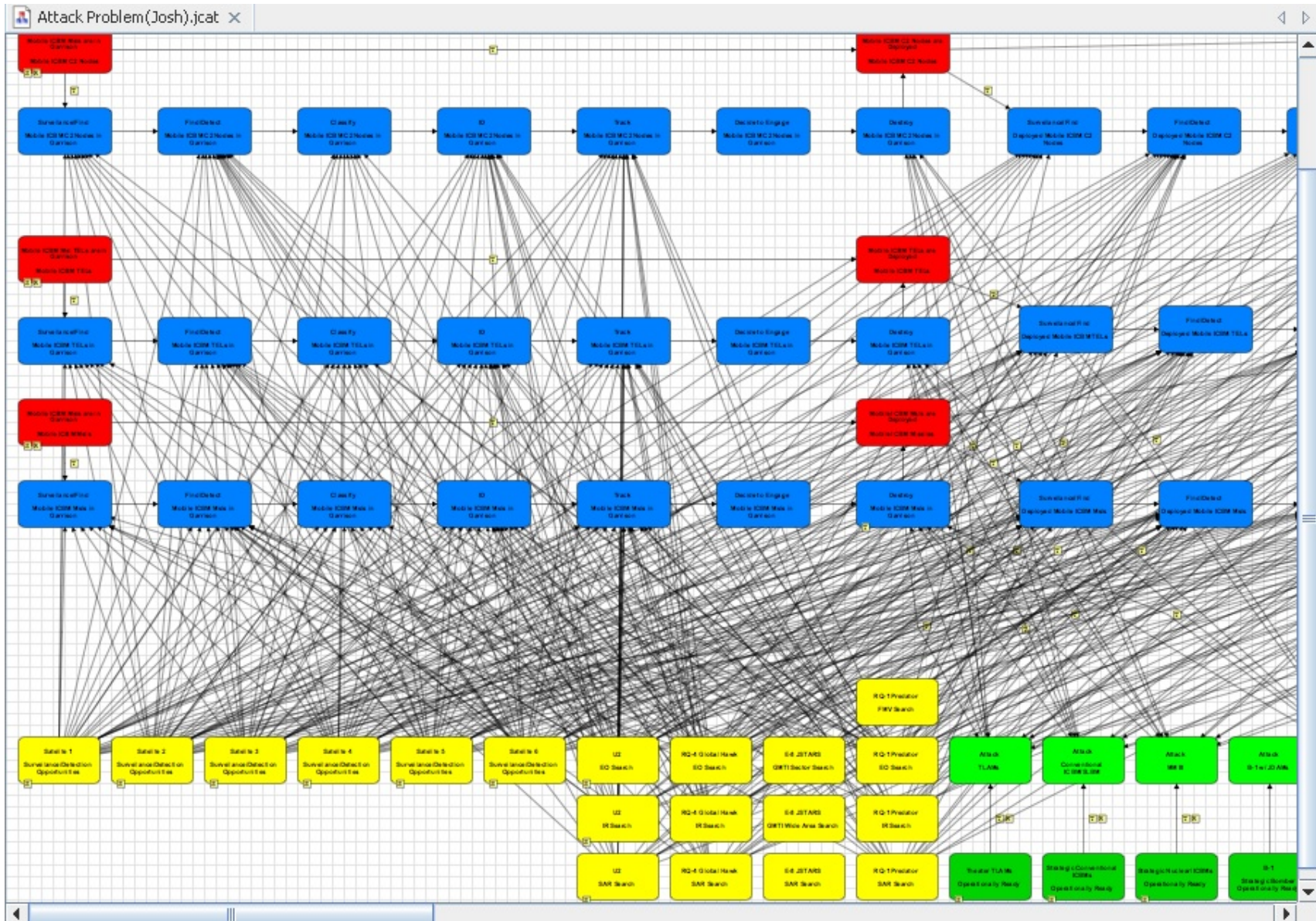
Two Ticks

Node	0	1	2	3	4	5
Available (B1's) [Process]	20.	0.	0.	0.	0.	0.
Available (B2's) [Process]	20.	0.	0.	0.	0.	0.
Available (JS 35) [Process]	20.	0.	0.	0.	0.	0.
Available (Rockets) [Process]	20.	0.	0.	0.	0.	0.
B1 Strike (null) [Consolidator]	7.	7.	0.	0.	0.	0.
B2 Strike (null) [Consolidator]	11.	11.	11.	11.	11.	10.284
Deployed (E/L) [Process]	0.	0.	0.	0.	0.716	0.716
Destroyed While Deployed (E/L) [Process]	0.	0.	0.	0.	0.703	0.716
Destroyed in Garrison (E/L) [Process]	0.	7.788	9.284	9.284	9.284	16.036
E/L Not Operational (null) [Signal]	0.	0.	0.	0.	0.703	0.716
Fire at (Us Good Guys) [Process]	0.	0.	0.	0.	0.716	0.716
In Deployed Position (null) [Signal]	0.	0.	0.	0.	0.716	0.716
In the crosshairs (null) [Signal]	0.	0.	0.	0.	0.716	0.716
JS 35 (null) [Consolidator]	13.	13.	10.	7.788	7.788	7.072
Killed (null) [Signal]	0.	7.788	9.284	9.284	9.284	16.036
Loaded (null) [Signal]	250.	250.	250.	250.	250.	249.284
Move Out (null) [Signal]	0.	0.	0.	0.	10.	0.
Opportunity to Fire (E/L In Garrison) [Process]	0.	10.	0.	0.	0.	10.
Opportunity to Fire (Deployed E/L) [Process]	0.	0.	0.	0.	0.716	0.716
Ready (null) [Signal]	0.	0.	0.	0.	0.716	0.716
Something to See (null) [Signal]	0.	10.	0.	0.	0.	10.
Targets Become Available (Erector/Launcher) [Process]	0.	10.	0.	0.	0.	10.

2 tic vs. 1 tic



Kill Chain for Missile Defense



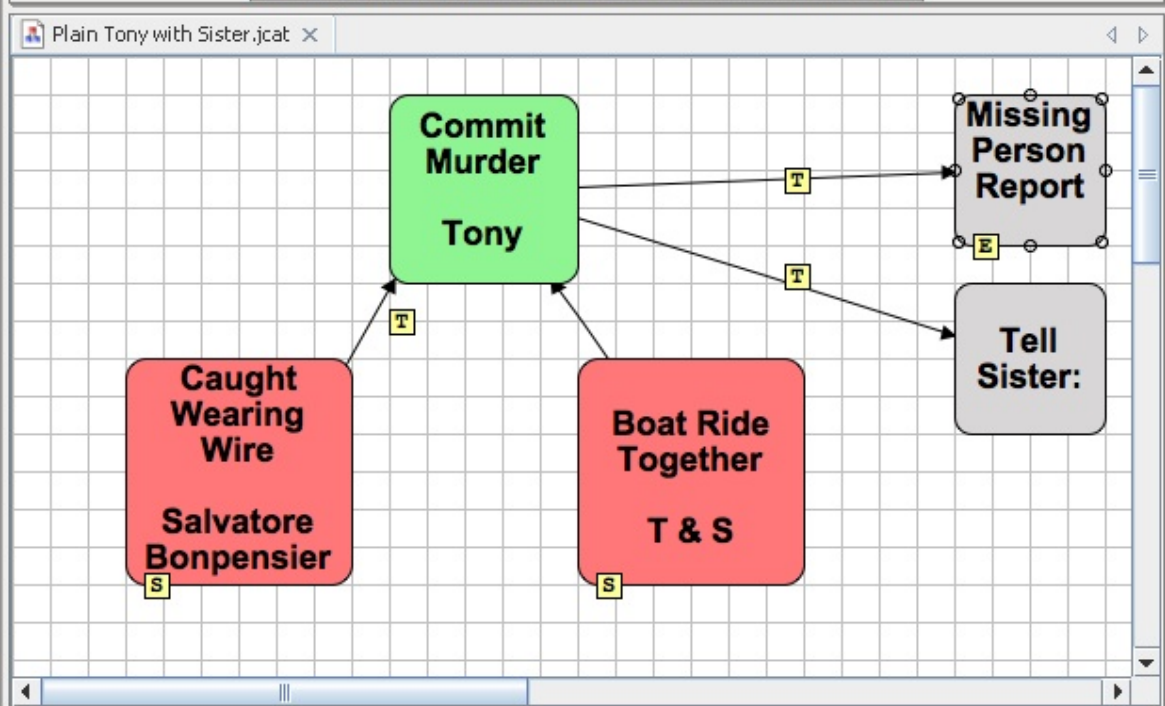
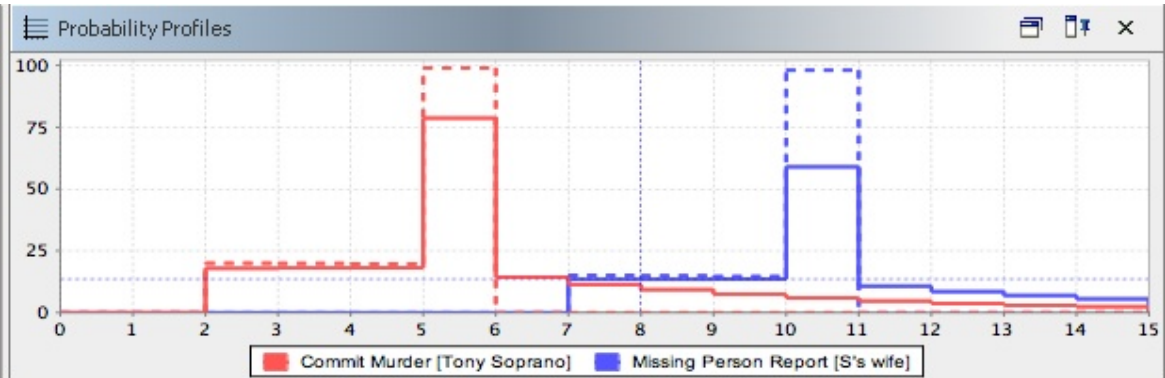
Bayes Network Types

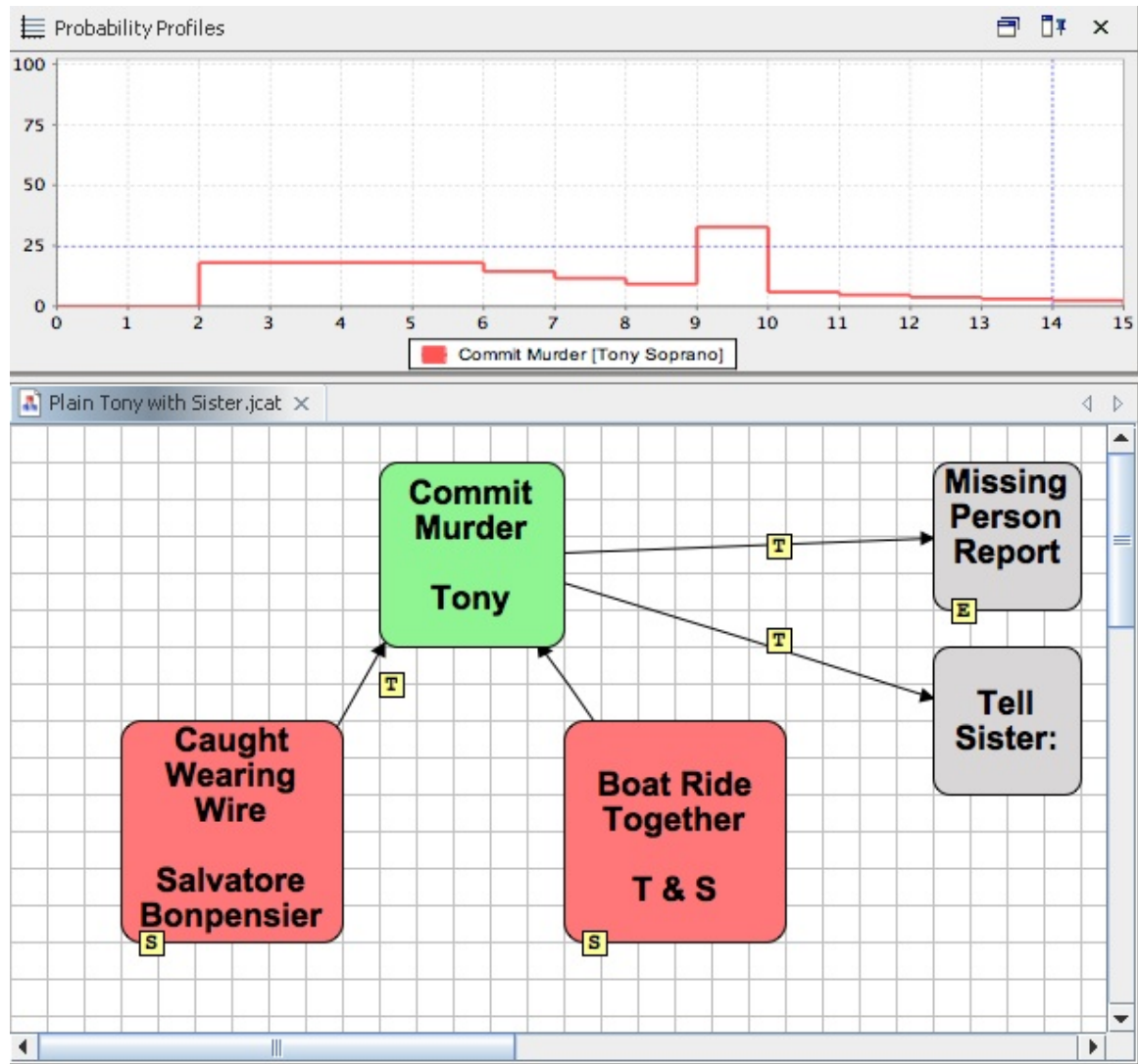
- Static Bayes Net
- Temporal (Dynamic) Bayes Net
 - Delay
 - Persistence
 - Fixed
 - Decaying
 - Resource Constrained
- Parallel Events Bayes Net
 - Ensemble

COA

Early Ride

Late Ride

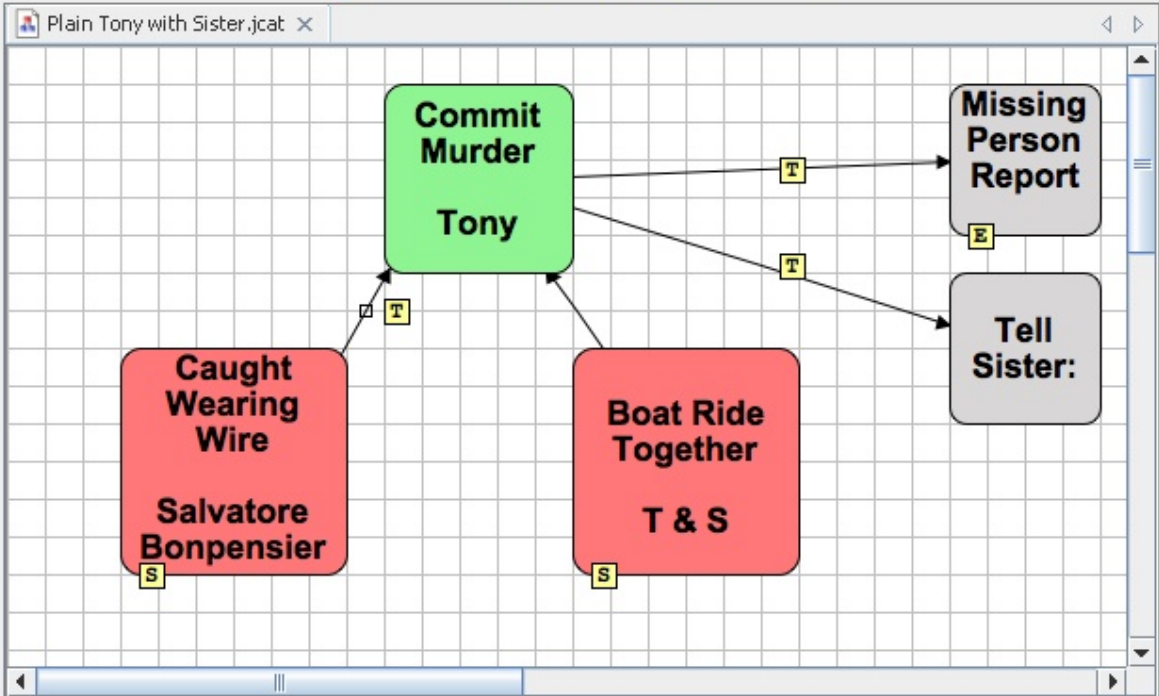
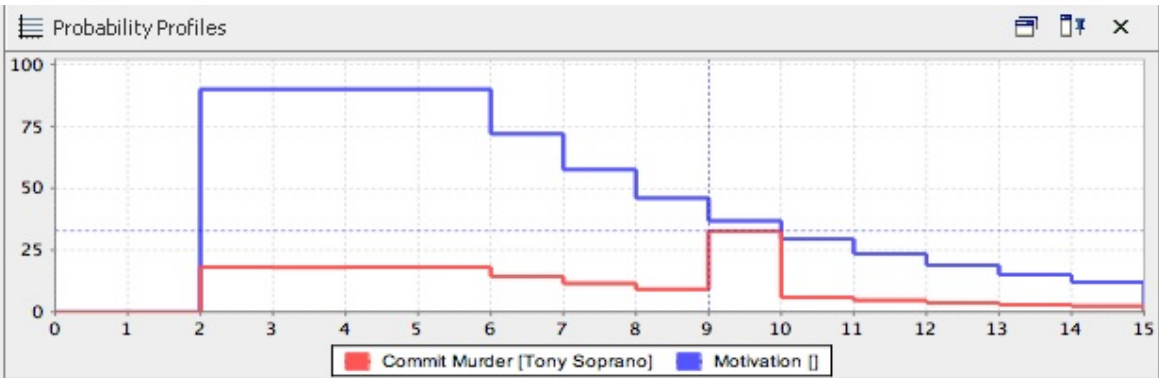




COA

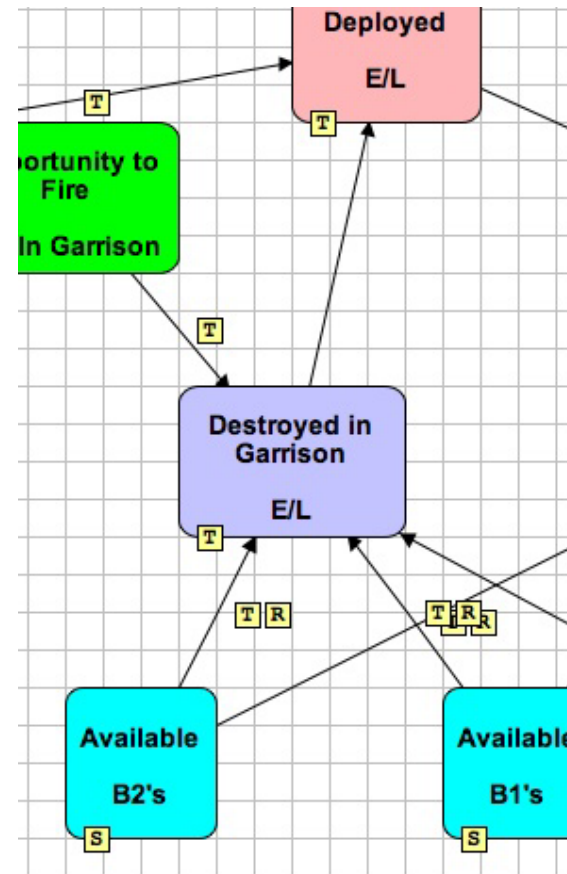
Early Ride

Late Ride



Resource Constrained Persistence

- How long does B2 availability persist?
 - At best until there are too many targets
- Number of targets?



Parallel Event Bayes Net

- Solve by sampling
 - Vice: Junction Tree Algorithm
- Ensemble Sampling
 - While still sampling
 - For each time step
 - For each threat
 - » Take a sample
 - Reset resources

Open Issues

- Target Weapon Pairing
 - Multiple Resource Usage Possible
 - Related to OR Gates
- Expending a resource
 - E.g. Attack vs. Destroy
- Re-firing
 - Technical Details
 - Policy

Comparison to Petri Nets, etc

- Petri Nets
 - At simulation level there are
 - Places
 - Transitions
- System Dynamics(Wikipedia)
 - Feedback
 - Accumulation of flows into stocks
 - Time delays

Advantages

- Clear Semantics
- Quick Build
 - Supports iterative refinement
 - Comparison of Alternatives
- Automated Support
 - Explanation
 - Sensitivity Analysis

Available

- To obtain JCAT
 - Contact either of the authors.